Transportation and regional inequality:

The impact of railways in the Nordic countries, 1860–1960.

ABSTRACT

Before industrialisation, the Nordic countries (Denmark, Finland, Norway and Sweden) were part of Europe's poor periphery, but over the last century these countries have become some of the richest in the world. This article analyses the origins of Nordic growth from the late-nineteenth century, focusing on a previously neglected topic: the role of transportation. We argue that transportation, and most notably large investments in railways, played a key role in Nordic industrialisation. Railways made the exploitation and exportation of natural resources possible in what had previously been isolated areas and helped fuel a process of rural-based industrialisation. By creating conditions that favoured migration towards previously scarcely populated, but economically booming areas, Nordic industrialisation was paralleled by a reduction in regional inequality as measured in per capita GDP. Railways were created *before local population growth* and helped shape the economic landscape of the entire region. The Nordic railway system is remarkable in that it helped exploit relatively deserted areas and create new towns. We demonstrate these points using maps based on HGIS highlighting railways, regional GDPs and population densities from the mid-nineteenth century until 1960

The Nordic countries (Denmark, Finland, Norway and Sweden) form Europe's northernmost geographical region and include some areas that even reach beyond the Arctic Circle.[1] Although peripheral in geographic terms and small in population terms, but over the last century these countries have become some of the richest in the world.

[1] Iceland, Greenland and the Faroe Islands are also often referred to as Nordic countries, but they have been omitted from this analysis due to a lack of data and the fact that their economic development and growth have mainly been due to factors other than railways.

This article will analyse the origins of Nordic growth since the mid-nineteenth century, focusing on a previously neglected topic: the role of transportation. We have looked at the Nordic countries together since they have shared a common path to industrialisation and growth, from the early exploitation of natural resources to supplying products higher up the value-added chain, and had made this region an industrial leader by the mid-twentieth century. According to Joel Mokyr, the region has followed the pattern of Small Successful European Economies.[2] Such economies combine openness to trade with specialisation in human-capital intensive niches in which they have established technological leadership. Although these four countries differ somewhat in terms of natural resource and historical governance, we argue that they share important commonalities, providing scope for a joint analysis.

In this paper, we argue that improvements in transportation were crucial to overcoming the previous constraints on the organic economy of such a geographically extreme region. Although the importance of transportation in this process had previously been stressed in the historical literature, by the likes of Hecksher, for example, its role had yet to be fully investigated for the whole of the Nordic region and the same was true of its impact on local growth and regional inequality.[3] Here, we stress three main areas in which large-scale investment in railways played a key role in Nordic industrialisation.

Firstly, the timing of the Nordic take-off to industrialisation and growth coincided with the construction of the area's railway networks; improvements in transportation were an integral part of the development of these economies. Secondly, railways made possible the exploitation and exportation of natural resources in what had previously been isolated areas, by reducing transport costs. Railways also supplied settlements with the food and energy needed to sustain growth. Before the industrial revolution, organic and climatic constraints meant that large cities were generally absent from the Nordic region. Furthermore, agriculture in the urban hinterlands was generally restricted in its capacity to feed a growing urban population. It was only through the expansion of the railway network that the limitations imposed by the climate and geographical isolation could be overcome. Railways stimulated urbanisation and they also reinforced the rural character of the Nordic economies by supporting a process of early industrialisation that was largely resource-based. In this region, railways were often built to connect natural resources to ports to facilitate exportation rather than to existing population centres, as elsewhere on the European continent. Thirdly, as a result of the rurally based and export-intensive industrialisation process, railways helped to access largely deserted areas and to create many new settlements. They were therefore often constructed *before local demand* and helped shape the long term economic landscape of the entire region.

Following a line of research on railways that exploits new GIS techniques, which was pioneered by Jeremy Atack, we will demonstrate these points using a newly created database based on HGIS combined with railways that have opened since the very start of railway construction.[4] [5] [6] Since Nordic countries are all well-equipped with long-run population statistics for consistent municipal borders, we will analyse the railway outcomes at a geographically detailed level, using population data from official statistical sources. For Norway, we collected data from Statistikkbanken from 1860 onwards. For Sweden we used the Umeå Demographic Data Base FOLKNET, with data from 1860 onwards. For Finland, the database on population at the municipal level was provided by the National Institute of Statistics which, as in the other countries, was homogenised to fit the current municipal map. However,

[2] J. Mokyr, Preface: Successful Small Open Economies and the Importance of Good Institutions, in: J. Ojala, J. Eloranta, and J. Jalava (Eds), *The Road to Prosperity – An economic history of Finland*, Jyväskylä, 2006.
[3] E. Heckscher, *An Economic History of Sweden*, Cambridge, 1954.
4 J. Atack, F. Bateman, M. Haines and R.A. Margo, Did railroads induce of follow economic growth? *Social Science History* 34:2 (2010) 171-197.
[5] J. Martí-Henneberg, European integration and national models for railway networks (1840–2010), *Journal of Transport Geography 26* (2013) 126-138.
[6] Our own database. *HGISe* project. University of Lleida. (see http://europa.udl.cat/)

the Finnish data series was only available from 1880 onwards. Population data for Denmark were harder to obtain for constant municipal borders and we therefore decided to exclude this country for the analyses that specifically pertain municipal population. We have provided additional population data for the largest urban agglomerations in all four countries from 1880 onwards, at ten-year intervals.[7] We have also included a newly created dataset of regional GDPs measured at the NUTS 3 level.[8] For most variables, we are able to go back to the mid-nineteenth and follow their evolution through the entire process of industrialisation. To our knowledge, this is the first time that such a large, detailed and long-run regional dataset has been presented for the Nordic region.

THE TAKE-OFF AND THE IMPORTANCE OF TRANSPORTATION FOR GROWTH

Before industrialisation, the Nordic countries were relatively poor and isolated and stood on the periphery of Europe. The majority of the region's population was predominantly rural. Towns were small, since the constraints of land and transportation meant that the size of any town was limited by the carrying capacity of its hinterland. In around the late-nineteenth century, rapid population growth in the Nordic region had resulted in a large landless rural underclass and some areas were probably at their Malthusian limits in terms of population density. As such, people were extremely vulnerable to any problem affecting domestic agricultural production. Indeed, poor harvests from 1866 to 1868 resulted in bad harvests and subsequent famine in northern Finland and also caused an economic crisis in northern Sweden. Historically speaking, a lack of transport often implied an increase in the severity of the resulting famine.[9] In addition, the cold winters of these northern countries ensured that energy requirements for heating were always high. It has been estimated that the annual household per capita consumption of firewood in Sweden was about five times greater than in Germany.[10] As none of the Nordic countries had any domestic coal reserves, saving land by substituting coal for firewood was not an option.

The situation initially facing the Nordic countries could perhaps best be described in the words of Tony Wrigley: 'trapped within the limits of the organic economy'.[11] In the absence of efficient long-distance transportation, their prosperity was initially dependent on the food and fuel provided by the domestic territory.

The pre-industrial transportation network was one of the main factors that initially constrained long-term growth. The roads in the region were clearly not up to European standards and overland transport was initially limited to pack animals and horse-drawn carts. It has been argued that the overland transport of high-weight-to-value goods, such as iron ore, was neither practical nor economically viable over distances of more than thirty kilometres.[12] Most transport activity had, therefore, to be confined to the winter months, when snow and ice provided the best surface for sleigh haulage. Although the region is well-endowed in terms of its potential for water transportation (pre-industrial long-distance trade routes from Scandinavia are well-known, mostly due to the travels of the Vikings between the ninth and eleventh centuries), its climatic conditions served as a limiting factor to sea transport. Large parts of the

[7] These are census data collected by the *eGeopolis* project led by Prof François Moriconi-Ebrard.
[8] See regional GDP sources in figure 2.
[9] M. Voutilainen, *Poverty, Inequality and the Finnish 1860s Famine*, Unpublished PhD thesis, University of Jyväskylä, 2016.
[10] A. Kander, P. Malanima and P. Warde, *Power to the People: Energy in Europe over the Last Five Centuries*, Princeton, 2014. See page 153.
[11] E.A. Wrigley, The transition to an advanced organic economy, *Economic History Review* 59 (2006) 435-480; and E.A. Wrigley, Reconsidering the 'Industrial Revolution', *Journal of Interdisciplinary History*, forthcoming.
[12] E. Heckscher, *Till Belysning af Järnvägarnas Betydelse för Sveriges Ekonomiska Utveckling*, Stockholm, 1907.

Bothnian Gulf were covered with ice during the winter months[13] and this severely limited market access to and from many Swedish and Finnish settlements for large parts of the year.[14]

The constraints on the organic economy in terms of land productivity and lack of access to efficient transport networks were the main reasons why the region's pre-industrial population tended to cluster in the south and around lakes and coasts. In these areas, soil quality was relatively good, access to water provided more efficient trading routes and fishing made a welcome contribution to the everyday diet.

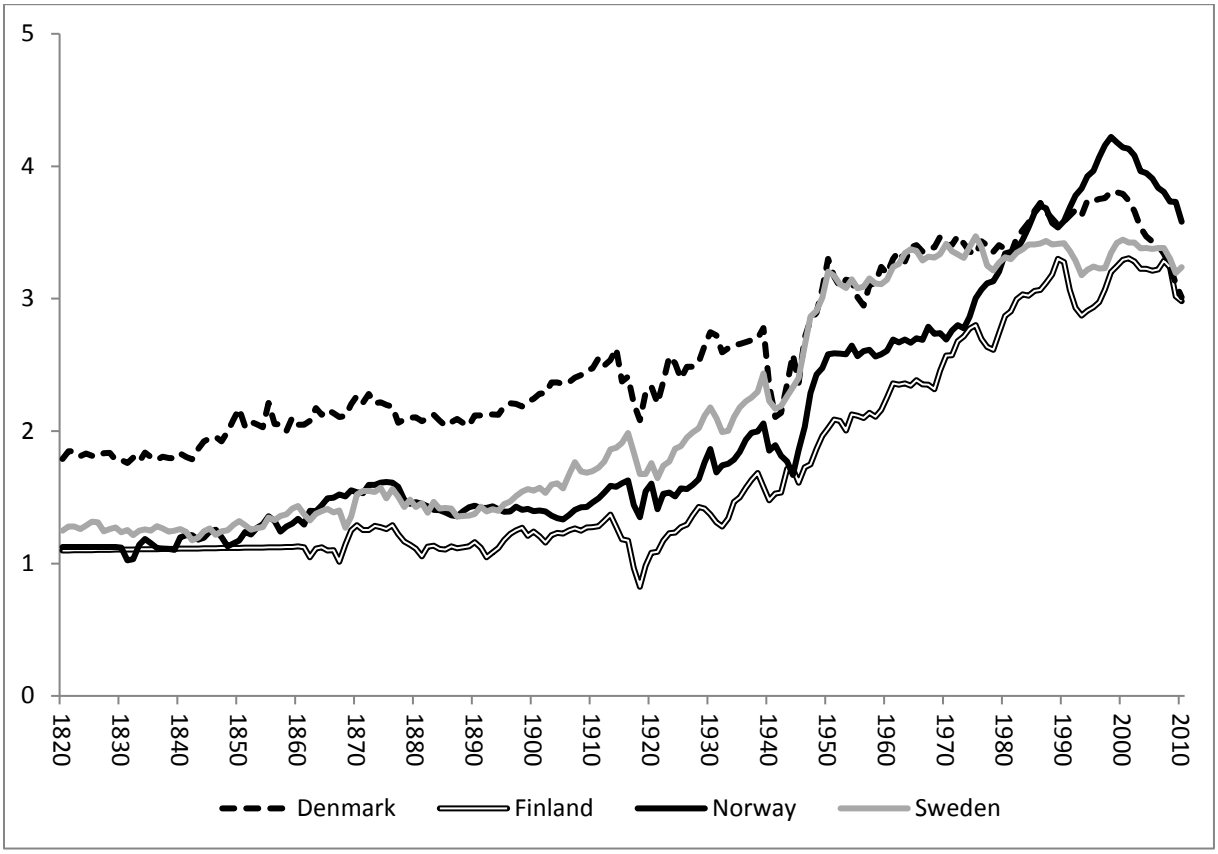


Figure 1. per capita GDP in relation to *world GDP* (Average world GDP =1). Source: *The Maddison-Project, http://www.ggdc.net/maddison/maddison-project/home.htm, 2013 version.* Note: The world GDP data have been linearly interpolated from the benchmark years of 1820, 1870, 1913, 1940 and 1950. Finnish GDP was interpolated from the benchmark years 1820, 1850 and 1860. Norwegian GDP was interpolated between 1820 and 1830. See Bolt and van Zanden for references to the dataset and original sources.[15]

The relative backwardness of the Nordic economy can easily be inferred from estimates of long-term GDP per capita. Figure 1 depicts these measures in relation to the world's total GDP, estimated from the Maddison database.[16] By 1820, Denmark was already somewhat ahead of the rest of the world in terms of its per capita GDP, whereas those for Sweden, Finland and Norway were on a par with the world average. However, by 1960 the Nordic countries had forged ahead and achieved levels of relative

[13] L. Leijonhufvud, R. Wilson, A. Moberg, J. Söderberg, D. Retsö, and U. Söderlind, Five centuries of Stockholm winter/spring temperatures reconstructed from documentary evidence and instrumental observations, *Climatic Change* 101:1 (2010) 109-141.
[14] The problem of ice-bound ports was not shared by Denmark and Norway because Gulf Stream ensures that the North Sea is almost always clear of ice. Better market access could perhaps explain the relative strength and success of the Norwegian shipping industry and the Danish economy in general at the beginning of the nineteenth century, as documented in: J. Ljungberg and L. Schön, Domestic markets and international integration: paths to industrialisation in the Nordic countries, *Scandinavian Economic History Review* 61:2 (2013) 101-121.
[15] J. Bolt and J.L. van Zanden, The Maddison Project: collaborative research on historical national accounts, *The Economic History Review*, 67:3 (2014) 627–651.
[16] Bolt and van Zanden, The Maddison Project.

per capita GDP that were twice, or even three times, greater than the world average.[17] This remarkable *take-off* can be dated to the late-nineteenth century.[18] In this article, we focus on the period from take-off until 1960, since that was when the greatest leap forward took place. By 1960, the Nordic countries had become established members of the world's most advanced economies and had started to distinguish themselves on account of their high government spending to GDP ratios and generous welfare states.

Table 1. Urbanisation ratios. Nordic countries

	1800	1850	1900	1950
Denmark	0.11	0.12	0.29	0.32
Finland	0.01	0.04	0.08	0.19
Norway	0.05	0.07	0.14	0.26
Sweden	0.05	0.06	0.13	0.26

Note: Urban population defined as living in settlements with more than 5000 inhabitants according to The Clio-infra database on urban settlement sizes: 1500-2000. To obtain urbanization ratios, we have divided urban population with total population figures from Maddison.

However, industrialisation remained predominantly rural based. Table 1 shows the share of population in the Nordic countries living in settlements with more than 5000 inhabitants.[19] In 1800, only eleven percent of the Danish population resided in settlements with more than 5000 inhabitants. In Finland, only one percent of the population lived in settlements larger than this and in Sweden and Norway the corresponding figures were around five percent. In fact, the populations of the capitals of Norway and Finland (Olso and Helsinki) did not exceed 5000 inhabitants until the nineteenth century. The absence of large cities prior to industrialisation clearly highlights the severity of the constraints placed on the organic economy. Before energy and food could be imported, settlement size was severely limited by the agricultural potential of their local hinterlands. As industrialisation progressed, and transport networks were improved, urbanisation increased.

By 1950, between one third and a quarter of the Nordic population lived in urban areas. However, since these countries started from such low levels of urbanisation, the share of people living in large towns remained modest by international standards. A considerable proportion of economic activity remained confined to rural areas until well into the twentieth century. Berger, Enflo and Henning have, for example documented the fact that sixty percent of all Swedish industrial workers resided in the country areas 1900.[20] As a result, opportunities to exploit economies of agglomeration remained severely constrained until well into the nineteenth century.

So, how can we account for the Nordic take-off and transformation from a relatively poor, predominantly rural region into one characterised by modern economic growth? Scholars have pointed to the Nordic countries as having been particularly successful due to the openness of their economies to trade and mass migration (as notably discussed by O'Rourke and Williamson).[21] The traditional view is that foreign demand, notably fuelled by British industrialisation, sparked off a handful of export-orientated industries based on primary resources located outside the main agglomeration areas (for

17 Finland had the least favourable early development. As a Grand Duchy of the Russian Empire it experienced a turbulent turn of the century until its declaration of independence in 1917. Nevertheless, there are indications of a spurt of growth during the late-nineteenth century.

18 J. Ljungberg, Nordic Countries: General Overview, in: *The Oxford Encyclopedia of Economic History* 4 (2003) 95-100.

19 http://www.cgeh.nl/urbanisation-hub-clio-infra-database-urban-settlement-sizes-1500-2000

20 T. Berger, K. Enflo and M. Henning, Geographical location and urbanisation of the Swedish manufacturing industry, 1900–1960: evidence from a new database, *Scandinavian Economic History Review* 60:3 (2012) 290-308.

21 K.H. O'Rourke and J.G. Williamson, Open economy forces and late nineteenth century Swedish catch-up. A quantitative accounting, *Scandinavian Economic History Review* 43:2 (1995) 171-203.

example in Jörberg, Hodne).[22] [23] In Denmark, the was a surge in the production of some agricultural products, such as barely and butter, from the 1840s onwards. The economies of Norway, Sweden and Finland expanded somewhat later, when a combination of increased access to transportation and foreign demand helped turn what had previously been seen as worthless forests into high-value export commodities. Iron ore and making iron products were back-bone industries in industrialisation, and particularly so in Sweden and Finland. Besides the production of sawn timber and iron, Norway also specialised in exporting fish products, while Sweden exported oats. According to the traditional view, the introduction of free trade, in around 1850, allowed these small, economically open, nations to offset the diseconomies of scale associated with their limited domestic demand. Railways played a major role in connecting areas endowed with natural resources to the main ports.

Transportation was thus crucial for the exports that fuelled Nordic industrialisation. However, allowing imports was also an important consideration. The Nordic countries all lack domestic coal supplies which meant that industry either required energy from water power or had to rely on imported coal. Henriques and Sharp have recently stressed the Danish dependence on imported coal during its industrialisation. This was made possible by cheap imports that could be shipped from Newcastle thanks to the close connection with Britain via the sea.[24] Even so, to transport this coal from the ports to their final destinations also required complementary investment in a Danish railway network. Also, it was not only coal that was imported. As these economies grew, consumption surged.[25] A growing home market fuelled the expansion of consumer industries such as textiles, food and tobacco. These consumer-oriented industries depended heavily on imported cotton, tobacco, sugar and other raw materials and the railways facilitated their influx.

The heavy dependence of export industries on natural resources, in combination with the growing dependence of consumer markets on imported raw materials, created a stark divide between export and home-market industries. This had consequences for regional specialisation. The location of natural-resource based industry was generally tied to places with the availability of raw materials and energy resources, such as access to water power. The development of the export sector therefore also helped to further strengthen the rural economy. In contrast, home-market oriented industries tended to locate closer to areas of local demand, and often within small, but growing, settlements. For example, the first mechanised cotton factory in the Nordic region was established in the Finnish town of Tampere, which soon developed a reputation as the *Manchester of the north*. Similar developments also took place in Oslo (then-called Kristiania), Norway, and at Norrköping in Sweden. Thus, Nordic industrialisation became a balancing act between the export-oriented rural areas and the growing agglomerations which specialized in the production of consumer goods to meet local demand.

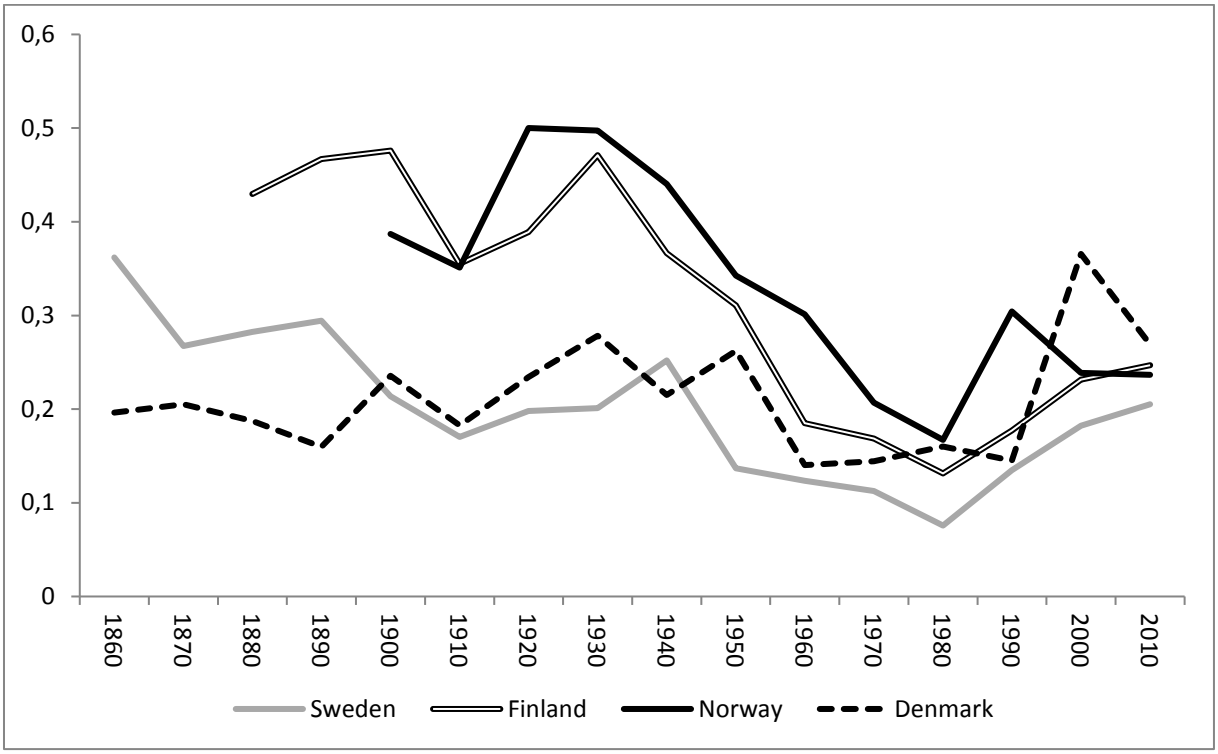
LONG-TERM GROWTH IN PER CAPITA GDP AND REGIONAL INEQUALITY

In 1965, Jeffrey Williamson formulated his famous hypothesis about long-term regional inequality.[26] Considering a large dataset of regional incomes between 1920 and 1960, he found a peak in inequality in the middle of the period studied. This suggested that the pattern of regional inequality during the

[22] L. Jörberg, The industrial revolution in the Nordic countries, in: C.M. Cipolla (Ed.), *The Fontana Economic History of Europe* 4:2, Glasgow, 1973, 375-485.
[23] F. Hodne, Export-led growth or export specialization?, *Scandinavian Economic History Review* 42:3 (1994), 296-310.
[24] S. Henriques and P. Sharp, The Danish Agricultural Revolution in an Energy Perspective: a case of development with few energy resources, *Economic History Review* 69:3 (2015) 844-869.
[25] Ljungberg and Schön, Domestic markets and international integration, 116.
[26] J.G. Williamson, Regional inequality and the process of national development, *Economic Development and Cultural Change* 13:4 (1965) 1-84.

process of industrialisation traced an inverted U-shape. This curve suggested a pattern of rising levels of regional inequality until a certain turning point, after which inequality would start to decrease, giving the shape of an upside-down letter U. According to the perspective taken, some regions appear as early developers in the industrialisation process, but a lack of integration between different regional markets will initially inhibit the diffusion of technological change. As a result, regional per capita GDPs will tend to spatially diverge. Further down the path to growth, the integration of markets and increased factor mobility will favour traditional equilibrating forces, resulting in convergence. In the long run, the path to inequality will look like an inverted U. That said, the data available at the time of Williamson's publication did not allow for any real long-term testing of this hypothesis. However, since 1965, Williamson's inverted U-shape has been largely confirmed for the long-term evolution of regional per capita GDP in Spain, Portugal and Italy, although less so for Belgium and Britain.[27]

The progression of industrial development in the Nordic countries did not follow a long-term inverted U-shaped pattern. In Sweden and Finland, the high levels of regional inequality that gradually diminished until 1980 had already been established. Figure 2 shows the long-term pattern for all four Nordic countries together. It can be seen that regional inequalities were large at the beginning of the industrialisation process in all of the countries except Denmark. However, while Sweden experienced a pattern of rapid convergence between 1860 and 1910, inequality levels in Norway and Finland remained high until after the Second World War. Denmark's development followed a flatter trajectory, with slowly rising levels of regional inequality until 1930. In the post-war period, there was then a strong process of regional convergence in all four countries that only came to a halt in 1980.



[27] Spain: J. Martinez-Galarraga, J.R. Rosés and D.A. Tirado, The Upswing of Regional Income Inequality in Spain (1860-1930), *Explorations in Economic History* 47 (2010) 44-257; Portugal: M. Badia-Miró, J. Guilera and P. Lains, Regional Incomes in Portugal: Industrialisation, Integration and Inequality, 1890-1980, *Revista de Historia Económica* 30 (2012) 225-244; Italy: E. Felice, Regional Value Added in Italy, 1891–2001, and the Foundation of a Long-Term Picture, *Economic History Review* 64:3 (2011) 929–950; Belgium: E. Buyst, Reversal of Fortune in a Small, Open Economy: Regional GDP in Belgium, 1896-2000, *Rivista di Storia Economica* 26:1 (2010) 75-92; Great Britain: N. Crafts, Regional GDP in Britain, 1871-1911: some estimates, *Scottish Journal of Political Economy* 52:1 (2005) 54-64.

Figure 2. Coefficient of Variation in regional per capita GDP (population-weighted). Note: Regions roughly corresponding to the NUTS 3 level. Sources: Sweden: Enflo et al. 2014 (twenty-four counties); Finland: Enflo (twelve historical regions); Norway: Modalsli (seventeen counties); Denmark: Janisse, Sandholt and Sharp (eleven counties).[28]

Low levels of regional inequality during the process of industrialisation set the Nordic countries apart from other cases in Europe and the USA. In these other economies, industrialisation was accompanied by forces that fostered agglomeration as well as driving economic growth and exacerbating inequality. In contrast, the rural-based Nordic growth model shows a more equal pattern. Previous literature has shown that internal migration from high to low-wage regions served as a balancing force during industrialisation.[29]

To understand the geographic scope of this process, we turn first to the maps of relative per capita GDP in figure 3. The initial year of analysis can be seen in the left-hand panel of the figure. Although different, due to data coverage issues, the maps show how large differences in per capita GDP existed between the regions containing the capitals and the rest of each country. The areas around Oslo, Stockholm and Helsinki all have well over twenty-five percent of their national average GDP. The poorest parts of each country in terms of relative per capita GDP are found in the south-east of Sweden, the interior of Finland and generally in the northern parts of each of the countries. In today's European Union, any region with a per capita GDP of less than 75 percent of the EU average is eligible for structural funds. The map shows that ten of the regions highlighted on the maps would have been eligible for such funds if there had been a similar policy for the Nordic region in the late-nineteenth century.

As we can see from the right-hand panel of figure 3, by 1960, the initial regional inequalities had diminished dramatically due to the impressive catching-up of many of the northern parts of the study region. While the most urbanised regions, and especially those around the capital cities, remained the most developed in terms of per capita GDP, their relative position weakened with respect to the national average. None of the regions now had levels of per capita GDP below 75 percent of the national average and some in the north of Sweden and Finland had even gone from having below average to above average levels of relative per capita GDP.

[28] Sweden: K. Enflo, M. Henning, L. Schön, Swedish regional GDP 1855-2000, Research in Economic History 30 (2014) 47-89; Finland: K. Enflo, Finland's regional GDPs 1880-2010: estimates, sources and interpretations, *Lund University Papers LUP* 135, 2014; Norway: J. Modalsli, Regional GDP of Norway, in J.R. Rosés and N. Wolf (Eds), *The Economic Development of Europe's Regions*, Routledge, forthcoming; Denmark: K.A. Janisse, P.S. Jensen and P. Sharp, Regional GDP of Denmark 1850-2010, in Rosés and Wolf, *The Economic Development of Europe's Regions*.

[29] K. Enflo, C. Lundh and S. Prado, The role of migration in regional wage convergence: Evidence from Sweden 1860–1940, *Explorations in Economic History* 52 (2014) 93–110.

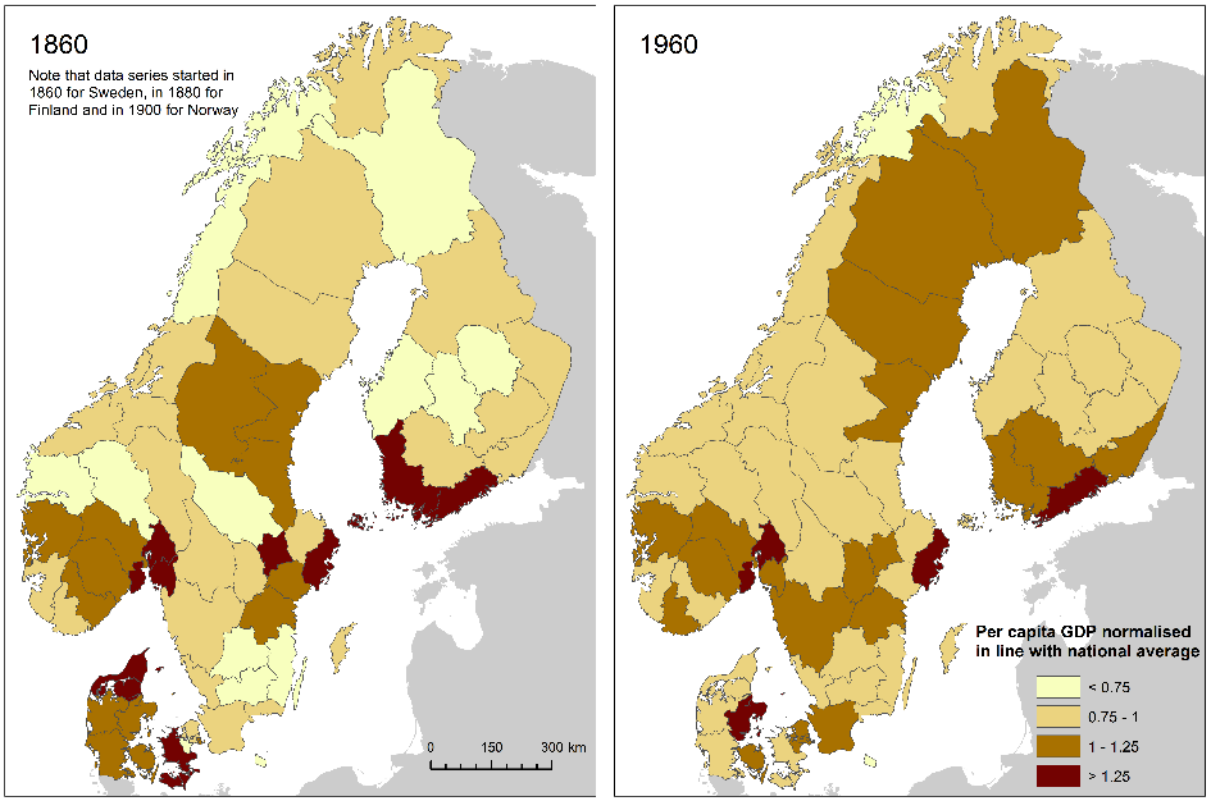


Figure 3. Regional per capita GDP normalised by national average. Sources: Sweden: Enflo et al. (2014); Finland: Enflo (2014); Norway: Modalsli (forthcoming); Denmark: Janisse, Sandholt and Sharp (forthcoming). Railways from HGISe project.

The process of catching up is even clearer from figure 4 which shows annualised growth rates for per capita GDP. The initial phase of regional growth clearly benefited the more backward regions in the southeast and the far north that we identified in figure 3. In contrast, per capita GDP in areas around Oslo, Stockholm and Helsinki grew only modestly. The first phase of industrialisation benefited rural areas in the far north, but also in the south. Henning, Enflo and Andersson have previously documented the vast geographical distances between the different Swedish regions that were taking off into modern economic growth.[30] This pattern of resource-based growth benefiting several areas outside the national capital seems to form part of a general trend in the Nordic countries.

Growth benefiting backward regions apparently mirrors the classical textbook version of unconditional β-convergence in which capital flows towards its highest marginal return.[31] As previously stated, what were initially the most backward and capital-scare regions of the Nordic countries tended to contain natural resources (mining, timber, oats) that could be exploited and then exported to foreign markets. Improvements in transportation technology played a key role in this process and influenced the forces that fostered convergence in relative per capita GDP. A map of the railway network as it was in 1860 and 1910 has also been included in figure 4 (we will discuss the morphology of the network in greater detail in section four).

[30] M. Henning; K. Enflo and F.N.G. Andersson, Trends and cycles in regional economic growth: How spatial differences shaped the Swedish growth experience from 1860–2009. *Explorations in Economic History* 48:4 (2011) 538-555.
[31] R. Solow, A Contribution to the Theory of Economic Growth, *The Quarterly Journal of Economics* 70:1 (1956) 65-94.

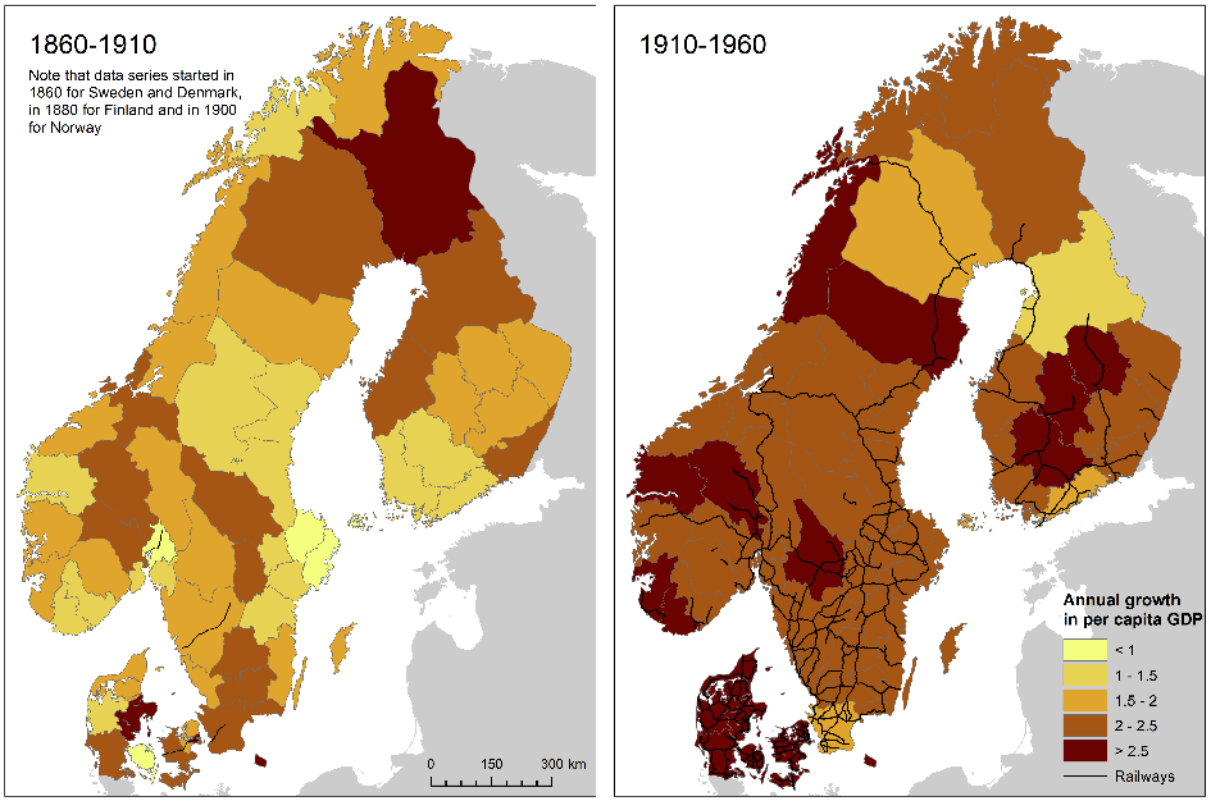


*Figure 4.*Annual growth rates in per capita GDP. Sources: Sweden: Enflo et al. (2014); Finland: Enflo (2014); Norway: Modalsli (forthcoming); Denmark: Janisse, Sandholt and Sharp (forthcoming). Railways from HGISe project.

The map shows that while there were only a few scattered railway lines around Oslo and in the south-west of Sweden in 1860, by 1910, the network had connected almost all the parts of these large countries. The railway networks were largely constructed to connect inland areas with port for export. This explains the important east-west oriented lines from the interior of northern Sweden to the ice-free port of Narvik on the west coast of Norway and the Finnish lines running though the interior of the country. As a result, between 1910 and 1960, some of the highest regional growth rates (sometimes exceeding annual rates of 2.5 percent) were observed in inland Finland, the northern-central part of Sweden and the north of Norway.

While causation between railways and regional growth is hard to prove, the maps show how railway lines were routed through inland areas which initially lacked growth potential during the early phases of industrialisation.[32] Between 1910 and 1960, however, these areas were booming and exhibited some of the highest regional growth rates observed in our sample. A rapid convergence in regional per capita GDP appears to have taken place in regions with rail connections by stimulating the diffusion of industrialisation, labour market integration and large flows of internal and external migration.

[32]More formal statistical tests following the pioneering approach by Atack et al,: Did railroads induce or follow economic growth?; have, however, suggested that causality may have actually run from rail to urban growth in the Swedish case, as explained in: T. Berger and K. Enflo, Locomotives of local growth: The short-and long-term impact of railroads in Sweden, *Journal of Urban Economics* 98 (2016) 124–138.

THE HISTORY OF THE NORDIC RAILWAY INVESTMENT

The nineteenth and early-twentieth centuries were the formative years in terms of the creation of the modern Nordic states.[33] Investment in railways quickly became part of the strategy of these newly formed states to promote their interests in economic development, military security and political unification. Despite differences in their political administrations, until the nineteenth century, all four Nordic countries were largely autonomous and this allowed them to make their decisions about the scope and shape of important national investments in infrastructure like railways.[34]

Some broad, general patterns of behaviour are easily discernible. Firstly, all the Nordic countries opted for state involvement at a relatively early stage. Within the main policy patterns identified by Bogart et al identify regarding railway investment prior to 1870, the Nordic countries stand out from the majority of European countries which opted for private ownership of railways combined with state subsidies and planning.[35] In contrast, Denmark and Norway started off with private involvement, but later shifted to direct state ownership and control, in the 1860s. Sweden initially decided on large-scale direct state involvement in both the planning and financing of its railways. Finland, as part of the Russian Empire, was to some extent influenced by Russian policies and practises concerning railway construction. The Finnish Diet also enjoyed a large degree of autonomy in its domestic policies and played a central role in railway planning from early on. For example, in 1872, the Finnish Diet voted in favour of state financing of the major trunk lines.[36]

Secondly, the discussions that preceded the construction of Nordic railway lines were often concerned with overcoming the geographical obstacles in the region. These included mountain ranges (Norway), straits separating the main islands and parts of the peninsula area (Denmark) and several lakes, rivers and swamps (Sweden and Finland). Combining these problems with cold climates and low population densities meant that the feasibility and profitability of investing in this type of technology was frequently called into question. This could perhaps, to some extent, explain why all of the Nordic countries opted for such a large degree of state involvement from early on.

[33] The Nordic region has a long-standing and largely common historical base, which started with the formation of the Kalmar Union back in 1397. There were then several border changes until the twentieth century. Sweden-Finland had already left the Kalmar Union in 1523, but Norway remained under Danish rule until the end of the Napoleonic wars. After that, Norway became part of a union with Sweden until its independence in 1905. Finland was incorporated into the Russian Empire, as a Grand Duchy, in 1809 but declared its independence after the Bolshevik revolution of 1917.

[34] The Finnish and Norwegian Diets were taking autonomous decisions about railway investments. Finland as a Grand Duchy of Russia had considerable autonomy over internal affairs, and the Swedish-Norwegian Union was a very loose construct that was mainly concerned with foreign affairs.

[35] D. Bogart, M. Drelichman, O. Gelderblom and J.L. Rosenthal, State and private institutions, in: S. Broadberry and K. O'Rourke (Eds) *Unifying the European Experience: An Economic History of Modern Europe*, Cambridge University Press, 2009.

[36] S. Zetterberg, *Mot gemensamma mål. VR 150 år*, Helsinki, 2012, 13.

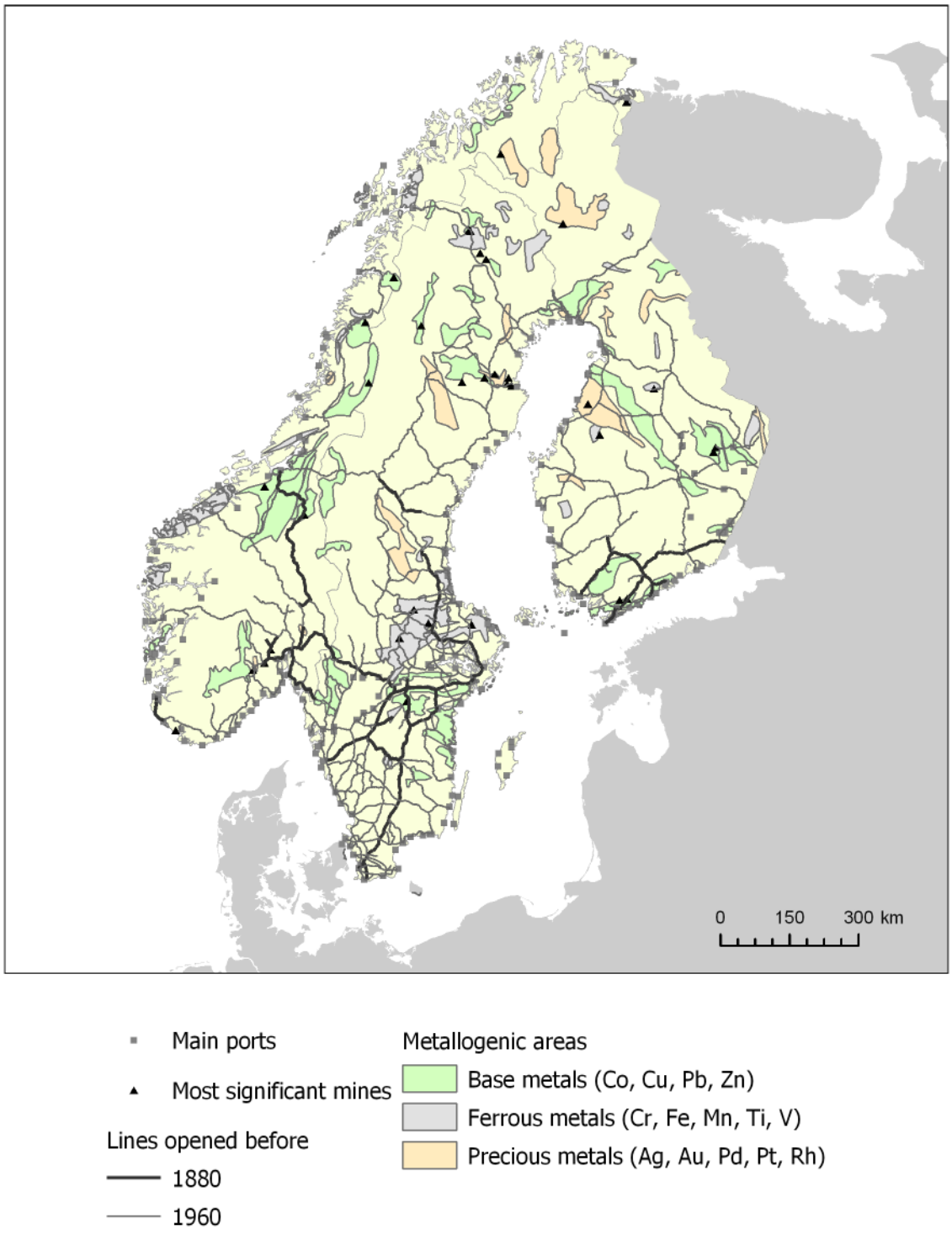


Figure 5. Distribution of mineral resources and the most significant mines in combination with the growth of the railway network 1880-1960. Sources: Railways from HGISe project, Urban Agglomerations from eGeopolis project, Minning resources and significant mines from Eilu (2012).[37]

Thirdly, Nordic railway lines were often projected inland rather than near to the coast. There were two obvious reasons for this. The first was that the prospectors of the time generally considered seaways a cheaper mode of transportation than inlands. As sea transportation had always been regarded as the

[37] P. Eilu, *Mineral deposits and metallogeny of Fennoscandia*, Geological Survey of Finland 53, Espoo, 2012.

superior mode of transportation, settlements located along the coast were also considered to provide superior access to markets. Instead of connecting the ports to each other, the priority was to connect the inland areas (which were often richly endowed with raw materials) to the ports. The map in figure 5 shows where the main mines and mining resources are located and how the railway network expanded between 1880 and 1960. The basis for industrialisation was the exportation of iron products and both iron (Fe) and copper (Cu) ore. There were also some smaller deposits of silver (Ag), but these were only of minor importance for the growth of the Nordic economy. As we can see from the map, many metal-producing areas and the most significant mines were located in the northern and inland parts of the Nordic countries; these were areas that had not been urbanised before industrialisation. Similarly, population and settlements expanded into inland and northern areas that had previously been virgin forests. It was possible to profitably exploit these resources once the railways had reduced the cost of transporting sawn timber to external markets.

The second reason why railways were often routed inland was a military consideration. Sweden's long eastern coast was considered particularly vulnerable to military attack and therefore the main northern trunk line was routed away from the coastal towns and any previous transportation routes.[38]

By 1880, all the Nordic countries had experienced a railway boom. The first years involved the building of many of state-sponsored trunk lines and were crucial for developing the morphology of the network.[39] Over the course of the development of the railway network, the trunk lines were supplemented by several complementary investments, and almost all parts of each of these countries eventually became connected by rail (see maps in appendix). Figure 6 shows the gradual expansion of the railway network, in terms of kilometres of track in service, until the mid-twentieth century, when it reached its maximum extension. In the second half of the twentieth century, rail closures became more frequent than the opening of new stretches of track. This left these countries with a relatively constant total length of the track in each of their rail network. Sweden, the largest nation of the four countries, built the longest absolute length of track, while the lengths of the railway networks in Norway, Denmark and Finland were similar. The Danish network was, however, by far the densest, as shown in the bottom panel of figure 6.

[38] L. Schön, *An Economic History of Modern Sweden*, Routledge, 2012.
[39] Berger and Enflo: Locomotives of local growth, have argued that the initial railway boom gave delivered a major shock to the system in Sweden. The first main state-sponsored trunk lines were so influential in determining the size and connectivity of Swedish settlements that they influenced their relative size and rankings in ways that persist until today.

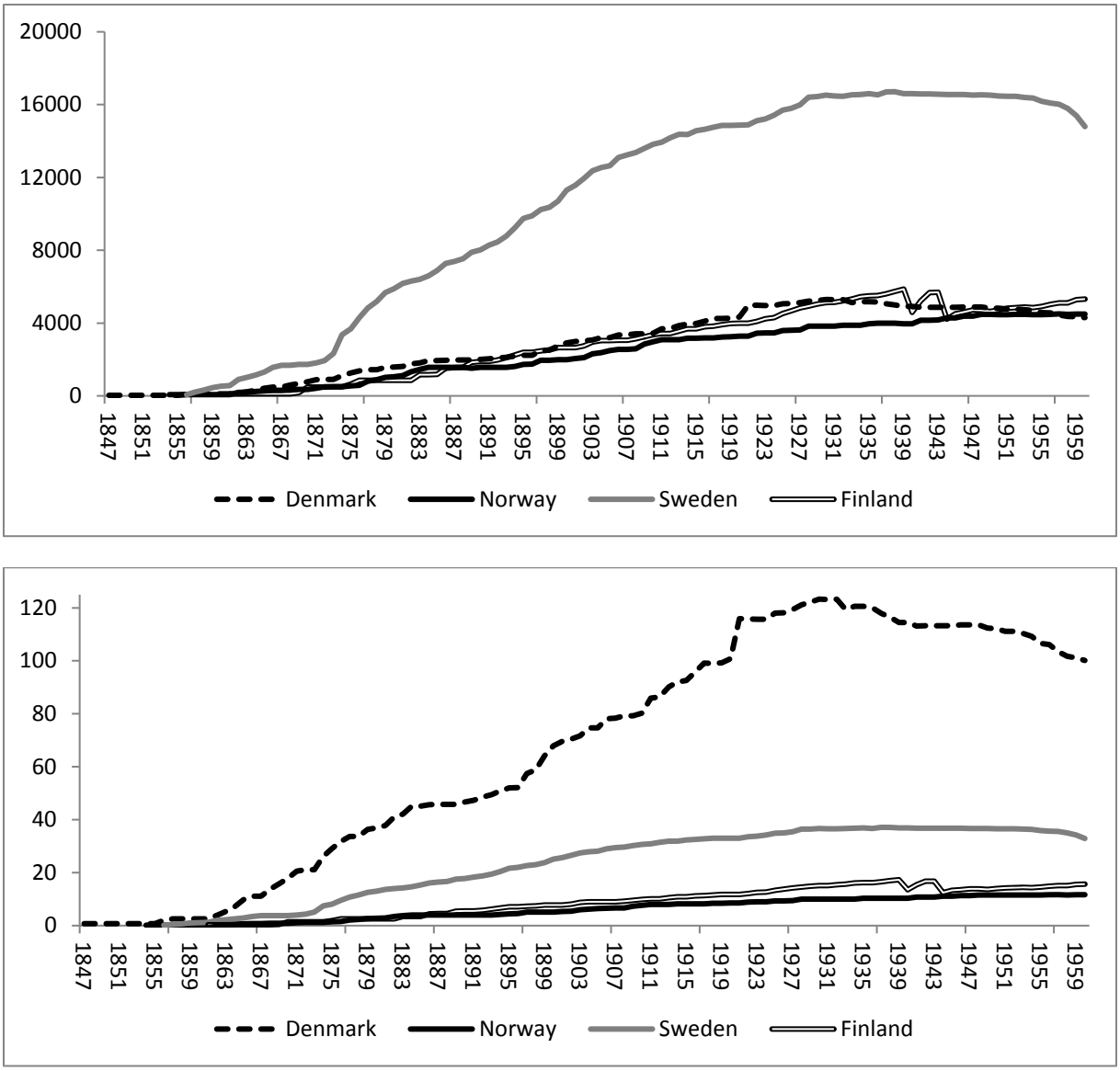


Figure 6. Length and Density of railway lines in service (in kilometres, in the top panel and in kilometres per area, in the bottom panel). Source: Mitchell (2007, 6th ed.), table F1, p.737-743

Taken together, the overall pattern suggests that the Nordic railway network was not only a response to pre-existing local economic requirements, but rather helped to shape these over time. In order to dig deeper into the specific circumstances and historical influences that governed the development of these networks, the next section will provide greater detail about each of the four counties on an individual basis.

Railway expansion country by country

The first Nordic country to build a railway was Denmark. This opened in 1844, but is now located in present day Germany, connecting Kiel to Altona, in the Duchy of Holstein. At the time of its construction, this area had been under the control of the Danish crown.

The next railway opened in 1847 and covered the trajectory between the Danish capital, Copenhagen, and Roskilde, some 30 kilometres away on the main island of Zealand. The initial funding for the Danish network came from private investors, but in 1867 much of the network passed into state control; in 1870,

only about 36 percent of the total length of track was owned by private companies.[40] Denmark's geography constituted a major challenge, since the three main parts of the country are separated by water. Thus, Denmark's first train ferry was inaugurated in 1872 to connect the island of Funen and Jutland peninsula. This ran across the waters of the "Little Belt" until 1935 when the first bridge was constructed. It was not, however, until 1998 that the bridge over the "Large Belt" opened to connect the easternmost island: Zealand to Funen and make it possible to travel between eastern and western Denmark by trains without the need for ferry connections.

Norway's first railway connected Oslo and Eidsvold, settlements some 70 kilometres apart, and was inaugurated in 1854. At the time of its construction, this was the only railway project in the country considered economically viable, since the Norwegian topography, with its large mountains and deep fjords, constituted a major obstacle for railway construction. In fact, at the time, steam boats were considered the cheapest option for transportation wherever they could be used. The Norwegian railways were therefore mainly built to connect inland areas to major ports. While the first railways were privately funded, the state became involved in the 1860s. The building boom of the 1870s was mostly financed by the Norwegian state borrowing from abroad. In 1870s, private companies owned only nineteen percent of the total length of track in Norway.[41] The construction of the Norwegian railway has a particularly interesting history. Although the first Norwegian railways were built to the European standard gauge (1,453 mm), a Norwegian engineer called Carl Pihl convinced politicians that later railway lines should be constructed at a narrower gauge (1,067 mm) in order to reduce costs. The only exception was when railway lines were to be connected to Sweden. At the time of railway construction, the eventual connection of all the different minor Norwegian networks was not foreseen. During the railway boom of the 1870s and 1880s, most of the new railway lines built in Norway were narrow gauge, leaving the country with two different and incompatible systems.[42] By around 1900, the situation had changed and it started to become more attractive to connect the isolated railway networks. Several major integration projects were initiated and between 1909 and 1949 all the narrow-gauge railways had been either closed down or converted to the national gauge, at a much higher cost than the initial saving obtained from using the narrower gauge. For a large part of the formative period of this new transportation system, Norway's domestic rail network was either unconnected or under construction. It would not, therefore, be unreasonable to expect that the Norwegian railway would not have had the same influence on shaping the country's geography as in the other Nordic countries.

Just like Denmark and Norway, Sweden initially planned to finance its railway system using private funding. The initial plans were supposed to be carried out by Adolf von Rosen, who sold shares in the Swedish Railway company to British investors in the 1840s. The Diet of the Estates granted von Rosen monopoly rights to build the national network upon the condition that a full plan of its coverage and financing should be presented by 1847. Unfortunately, the British railway bubble burst in 1846 and the finances for the proposed Swedish network therefore evaporated overnight. Instead, the Diet decided to build and finance the network mainly through state funding. The engineer Nils Ericson, who was a brother of John Ericsson of Monitor fame and a *born leader*, was appointed to do the necessary work and presented an alternative plan for the network by 1853.[43] When this plan was made public, it was heavily criticised for its *horror of waterways and cities* (ibid), as many lines were routed through deserted inland regions without much potential for economic growth while many historically important towns were left unconnected. The design of the main trunk lines therefore constituted an interesting case

[40] D. Bogart et al, State and private institutions, 93.
[41] D. Bogart et al, State and private institutions, 93.
[42] T. Bjerke and R. Stenersen, *Rørosbaneboka*, Hamar, 2002.
[43] E. Hecksher, *An Economic History of Sweden*, Harvard University Press, 1954, 241.

of applied regional policy because the railway lines were not projected to connect the most economically important cities.[44]

The first railway link between Helsinki and Hämeenlinna (covering 100 kilometres) opened in 1862.[45] The next one connected Helsinki and the then Russian capital of St. Petersburg. This was a link that had been considered for some time, but no real progress was made until 1867 when Tsar Alexander II issued a decree calling for its construction and stating that Riihimäki (a station on the Helsinki-Hämeenlinna line) would provide the main connection to St Petersburg. This somewhat arbitrarily chosen location, situated some 70 kilometres north of Helsinki, thereby became an important junction and the town of Riihimäki was created and grew as a result of its favoured position within the network.[46] The 370-kilometre-long rail link between Riihimäki and St Petersburg opened in 1870 and was the responsibility of the Finnish Railways. Even so, it was not until 1912 that the Finnish and Russian rail systems became properly connected. As it formed part of the Russian empire, Finnish track was set at the broad Russian gauge (1,524 mm). As Sweden operated on the European standard gauge (1,435 mm), connections to Sweden did not open until 1919 and, ever since, trains have had to adjust their wheels to the change in gauge width at the border.

TURBULENCE IN POPULATION DISTRIBUTION

In the introduction, we suggested that railways have shaped the economic landscapes of the Nordic countries. In figure 7 we make this point clearer with the aid of a map. This shows the largest fifteen urban agglomerations ranked by size in 1880 and 1960.[47]

If the railway network had merely been a response to economic conditions, we would have expected the first railway lines to connect what were the largest areas back in 1880. Thereafter, forces favouring agglomeration would have worked to sustain the growth of already prosperous municipalities, leaving the overall ranking of urban agglomerations relatively unchanged until 1960. Such long-term persistence in regional rankings is often documented in historical literature (for example, by Davis and Weinstein).[48] However, the regional rankings for the fifteen largest urban agglomerations in the Nordic countries show a surprising level of turbulence over the study period. It is also evident that in many cases the railways avoided what were the largest urban agglomerations of the time. This is particularly visible in the case of Sweden, where none of the junctions on railway lines running east-west that crossed lines running north-south were at locations that figured amongst the country's fifteen largest urban agglomerations in 1880. Similarly, in Finland, the 1880 network did not connect any of the large population centres located in the country's Lake District (eastern interior), nor along its west coast. Neither was there any direct rail connection between Finland's capital, Helsinki, and its second largest city, Turku (which had been the Finnish capital until the early-nineteenth century and was a town of great historic importance). In fact, of the fifteen largest urban agglomerations in Finland, only four were connected by rail in 1880.

By 1960, several new cities had entered the list of the top fifteen settlements in each of the Nordic countries. The turbulence in these rankings was greatest in Finland (with nine new entries), followed by

[44] Berger and Enflo, Locomotives of local growth.

[45] See also O. Kotavaara, H. Antikainen and J. Rusanen, Urbanization and Transportation in Finland, 1880–1970, *Journal of Interdisciplinary history* 42:1 (2011) 89-109; for an analysis of the relationship between railway infrastructure and population change in Finland from 1880 to 1970

[46] Zetterberg, Mot gemensamma mål. VR 150 år.

47 Data for population obtained from the aggregation of census data for municipalities with contiguous urban fabric within less than 200 metres and where the total population of the main nucleus is more than 10,000 inhabitants (e-Geopolis project).

[48] D.R. Davis and D.E. Weinstein, Bones, Bombs, and Break Points: The Geography of Economic Activity, *American Economic Review*, 92:5 (2002) 1269-1289.

Sweden and Denmark (six and five, respectively). By this time, almost all of the largest population centres had a railway station, with many being located at a junction. In 1960, northern Finland, northern Sweden and western Denmark (Jutland) all had urban agglomerations amongst their country's top fifteen settlements that had made it into the ranking since 1880 (visible as lighter grey circles in figure 7).

The main exception to this general pattern was Norway. This country exhibits the greatest persistence in size rankings, with only four new urban agglomerations entering its top fifteen between 1880 and 1960. Indeed, two of these new entries (Tromsø and Ålesund) remained unconnected by rail until 1960. In Norway, railway lines were essentially constructed to connect existing ports, but appear to have failed to stimulate the emergence of any major new agglomerations in inland areas. One reason for this may have been the fact that the early combination of narrow and standard gauge railways failed to create an integrated domestic network. Much of the early twentieth century was spent rebuilding the narrow-gauge railways, but this may have limited their transformative power and ability to influence the town building evident in the other Nordic countries.

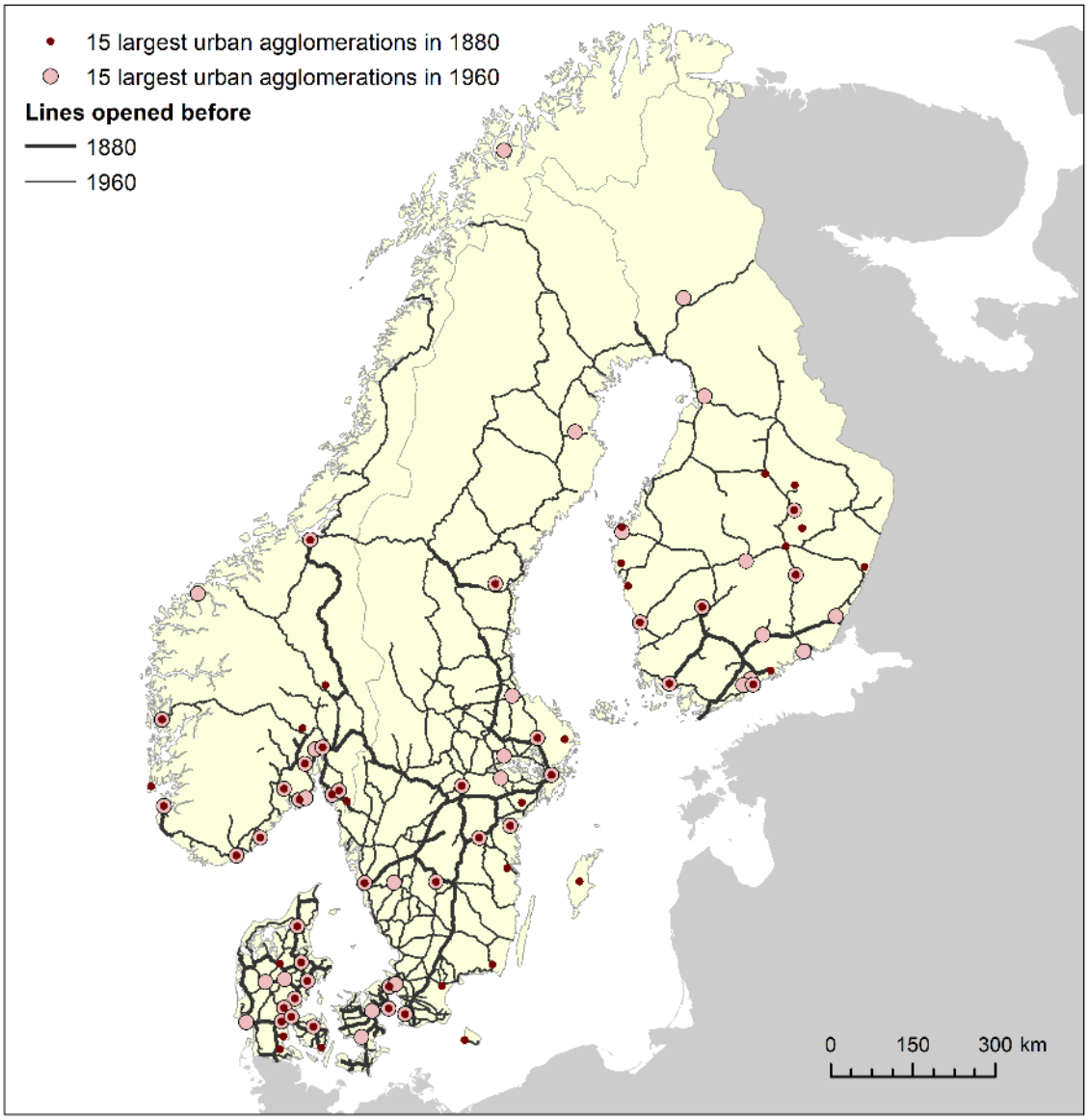


Figure 7. The fifteen largest urban agglomerations in 1880 and 1960. Railway network in 1880 and 1960. Sources: Railways from HGISe project, Urban Agglomerations from eGeopolis project.

Having established this pattern of long-term turbulence in the regional rankings of the fifteen largest urban agglomerations in each of the Nordic countries, we now turn to the broader issue of how railways have influenced the broader pattern of population growth. We have done this using the entire database of 455 municipalities, with reference to constant borders and measuring changes at ten-year intervals.

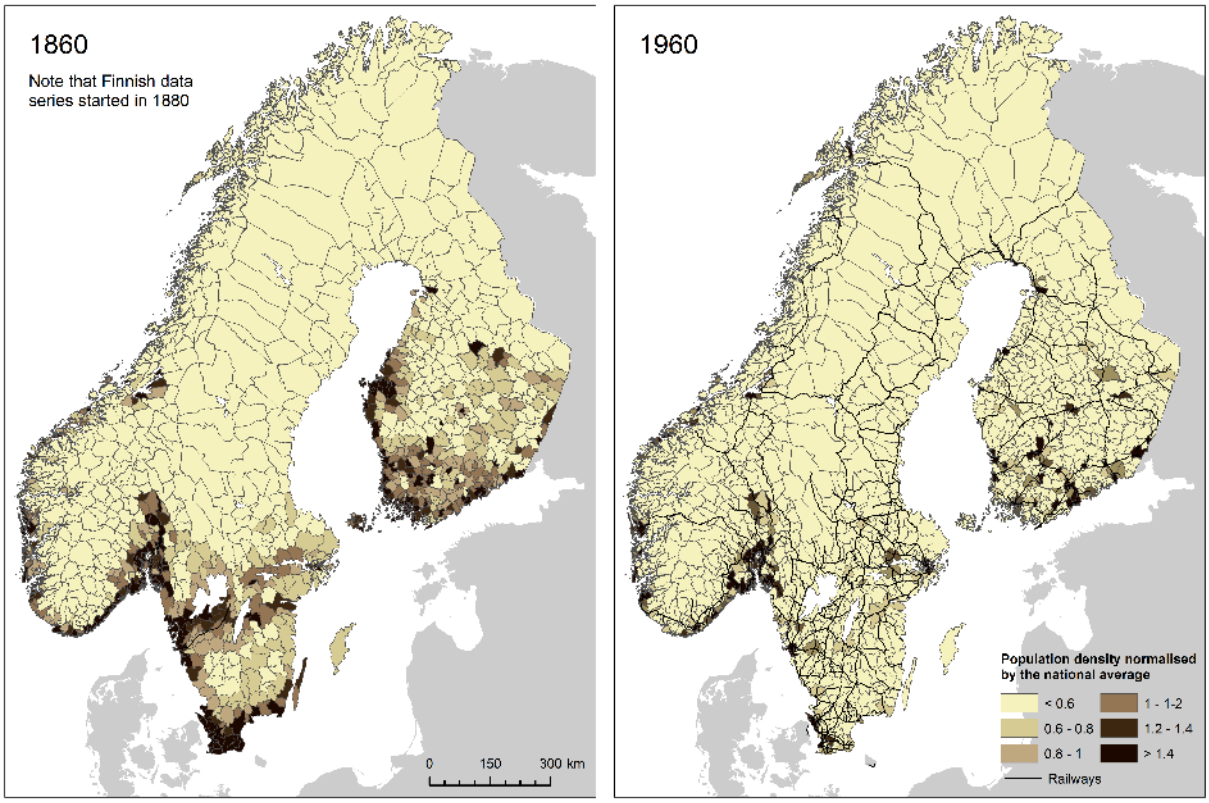


Figure 8. Distribution of population density in 1880 (left panel) and 1960 (right panel). Railway network in 1860 (left) and 1910 (right). Sources: Norway: Statistikkbanken; Sweden: Umeå Demographic Data Base FOLKNET, Finland: National Institute of Statistics. Railways from HGISe project.

Figure 8 shows the population density of the municipalities normalised at national average values for 1880 and 1960. Population density was less equally distributed in 1880 than in 1960. We can see that the main centres of population were initially clustered in the southern parts of Finland, Norway and Sweden and particularly along their coasts. In general, the interior areas were less populated, except for the areas between the major lakes in Sweden and around the Finnish lake land in most of most of the central and East Finland. Lakes were important transportation routes in pre-industrial times and also offered potential for fishing and, in some cases, access to water power for the production of manufactured goods or iron.

The geographical balancing of population between 1880 and 1960 was driven by two factors: emigration and internal migration. Both were facilitated by improvements to the transport network. If we start by considering the role of emigration, it should be noted that some areas were probably near their Malthusian limits, in terms of population density, during the nineteenth century. For example, the devastating Finnish famine of the mid 1860s suggests the fragility of the land in supporting a large population. As transportation networks improved, emigration became a natural choice for some members of the landless underclasses. Between 1850 and 1914, about 1.2 million Swedes, 0.7 million Norwegians, 0.3 million Danes and 0.3 million Finns crossed the Atlantic to seek better opportunities

in North America.[49] Emigration was a regionally concentrated phenomenon. In Sweden, many of those emigrating were from the densely populated, but poor, areas of the rural south-east (counties like Kronoberg, Kalmar and Blekinge), while the Finns who emigrated were mainly from the western coastal area known as Ostrobothnia. These areas were relatively densely populated in 1880, but were not so relevant in terms of relative population density in 1960 (figure 8). The combination of railways, internal migration and emigration in the late nineteenth century provided a balancing force that evened out population densities.

Secondly, internal migration meant that previously sparsely populated regions in the north of these countries began to grow. The booming forest regions were sometimes referred to as *Little America* or *The Klondyke of the North* and so migrants chose between moving north or emigrating. The effects of this internal migration are visible in the rates of population growth shown in figure 9. The first period of railway building led to a relative increase in population in the northern territories, especially in Finland and Norway. This increase was strongest between 1900 and 1920 (see poster 4 in the appendix), when the railway network had fully extended into the northernmost parts of all the Nordic countries.

Finally, a note of explanation is required as to the remarkable growth of Finland's population in the 1940s and 1950s (see poster 5 in the appendix). Due to cessions of territory after the Second World War, when Karelia was annexed by the Soviet Union, 430,000 people (about eleven per cent of Finland's population at the time) had to be evacuated. These displaced Finns were allotted new farmland in Finland according to government designed legislation: the Sarvimäki documents. The evacuation generated economies of agglomeration and externalities in terms of population growth and industrialisation in the area in which these people settled.[50] Thus, one of the effects of the resettlement plan was the creation of a large number of small farms that spread across Finland and probably helped to further increase regional equality in terms of population density.

[49] Ljungberg, Nordic Countries: General Overview.
[50] M. Sarvimäki, Agglomeration in the periphery, *Spatial Economics Research Centre LSE*, series SERC 0080, 2011.

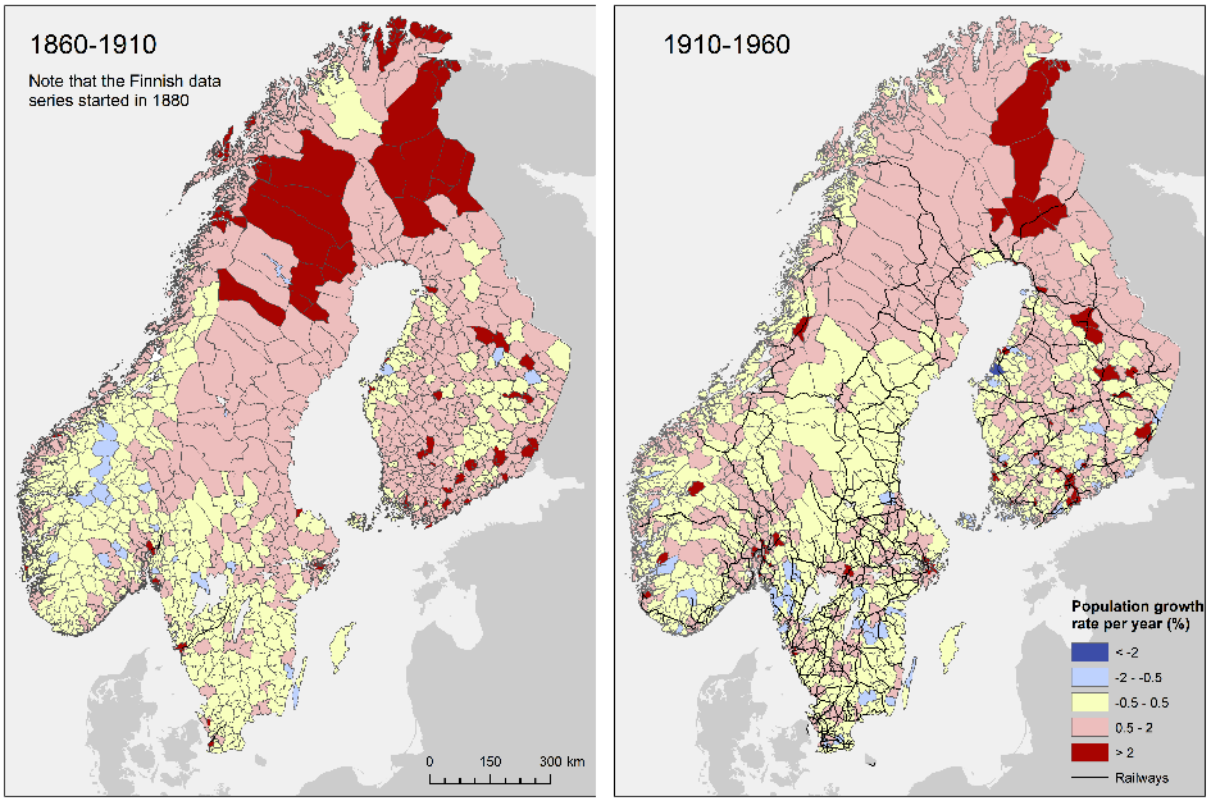
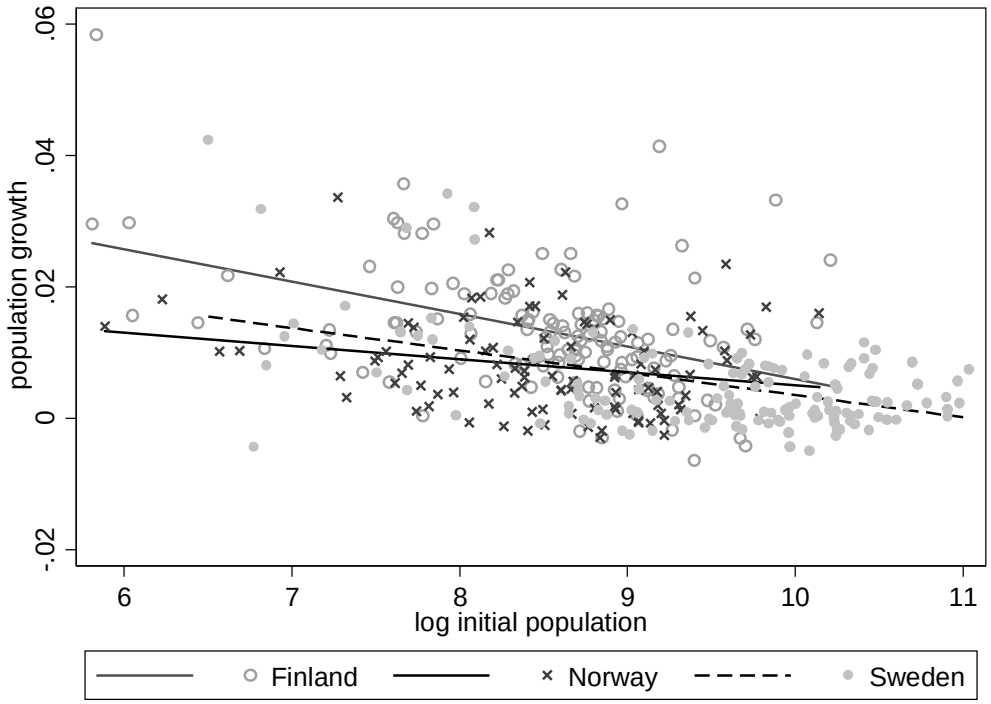


Figure 9. Population growth rates for the periods 1860-1910 (left panel) and 1910-1960 (right panel). Railway network in 1860 (left) and 1910 (right). Sources: Norway: Statistikkbanken; Sweden: Umeå Demographic Data Base FOLKNET, Finland: National Institute of Statistics. Railways from HGISe project.

The panel on the left in figure 9 shows that population growth in the northern inland areas of Sweden and Finland (and to a lesser degree in Norway) continued well into the 1960s, when the expansion of the northern regions came to a sudden halt.

In general, the maps show major population growth in areas with low initial population densities, especially during the period 1910-1960. This catching up process in terms of population growth in the most sparsely populated municipalities can also be shown by the process of β-convergence. This type of evolution is shown in figure 10, where the log of the initial population (1860/1880) is shown on the x-axis, with population growth on the y-axis. The dataset covers all the municipalities (454) in Norway, Sweden and Finland that are shown on the maps in figures 8 and 9. Several municipalities with initially very low levels of population exhibited some of the highest growth rates in both periods, although the pattern was stronger for 1910-1960 than for the earlier period. There was a marked β-convergence in Finland, Norway and Sweden, with the slope being most negative for Finland in both periods. This evolution reinforces our argument that railways facilitated the process of populating previously sparsely populated regions and helped to balance population rather than driving agglomeration economies.



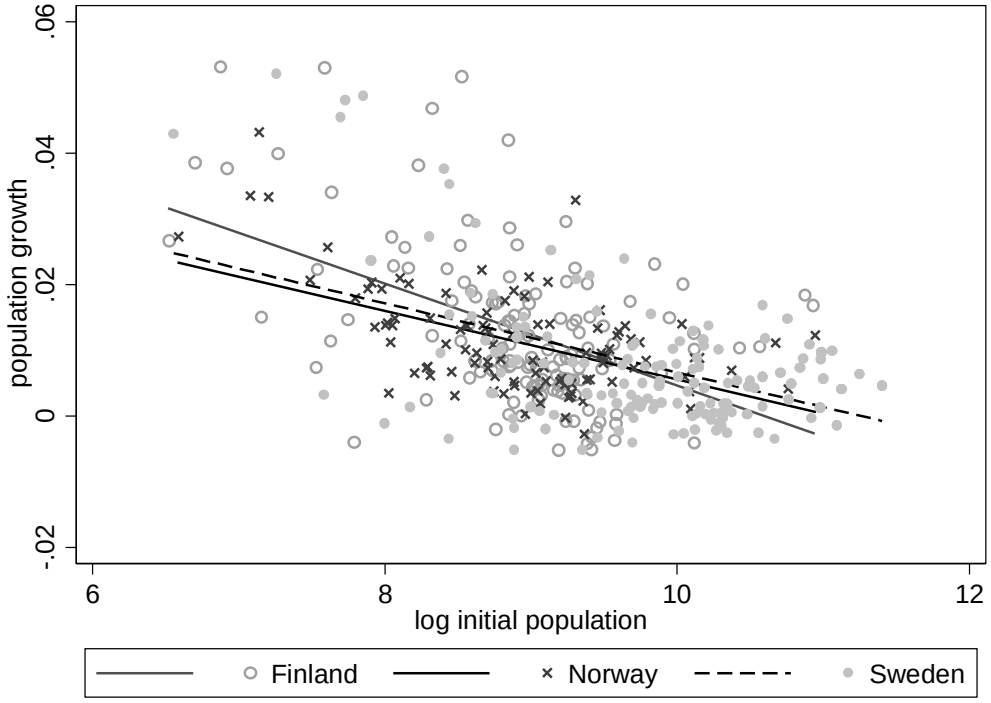


Figure 10. β-convergence population in Nordic municipalities, top panel: 1860-1910, bottom panel 1910-1960. Note: The Finnish data series began in 1880. Sources: Norway: Statistikkbanken; Sweden: Umeå Demographic Data Base FOLKNET, Finland: National Institute of Statistics.

CONCLUSIONS

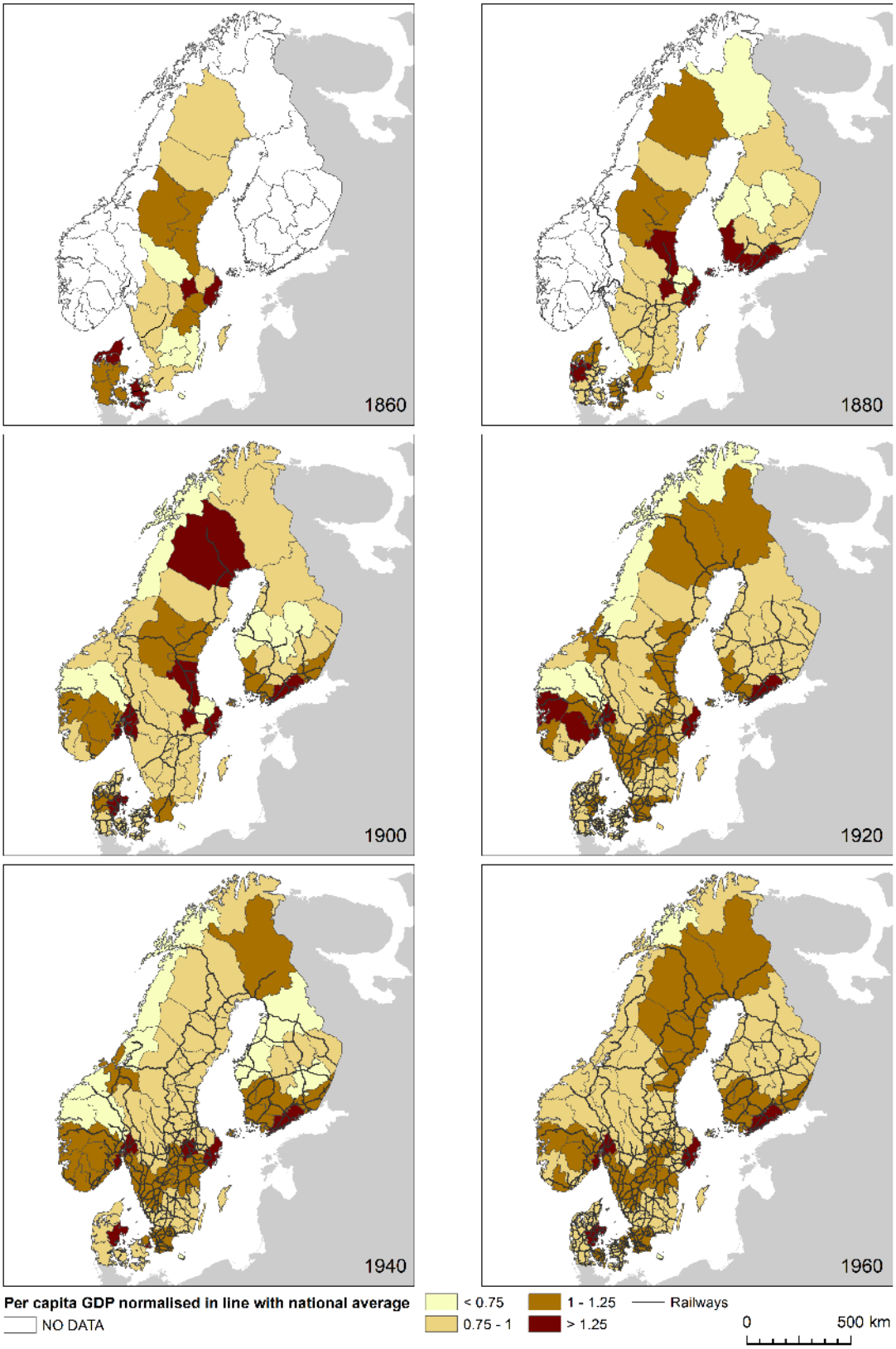
Within a period of one hundred years (1860 to 1960), the Nordic region changed from being part of Europe's poor periphery to becoming one of the world's most prosperous economies. Its take-off occurred in the late-nineteenth century and has often been attributed to export-demand from the growing British economy; however, domestic market forces, fuelled by imports were probably also important. Neither exports nor imports could have been sustained without major improvements to its transport system. Without access to transportation, the area was initially trapped within the limits of an organic economy which relied heavily on domestic production to meet its economies' food and energy requirements. Improvements in transport made expansion into previously sparsely populated regions possible by connecting distant areas to food, energy and export markets. In the words of Eli Hecksher, transportation was probably more important than the open economy policy of free trade that has so often been stressed in the literature as the main source of Nordic growth.[51]

In this article, we have demonstrated that the construction of railways predated population growth in many parts of the Nordic region and that the basic railway network certainly had an influence on the long-term distribution of population. At an early stage, all the Nordic countries opted for a railway network that was highly influenced by state planning and financing. The objectives of these state planners were not only to connect existing population centres. Political and military concerns, as well as a quest to exploit natural resources often determined the morphology of the respective national networks. By constructing railway lines and critical junctions in previously backward areas, the rail networks shaped the industrial geography of these countries and the rankings of their urban agglomerations in the twentieth century. While some previously important town were neglected by the network, many new growth poles were established around railway nodes. As a result, the railways helped to balance population density in terms of geographic coverage. The effects of the railways remained throughout the period studied, showing that the creation of local *prospects for growth* were capable of having lasting effects. In consequence, we have documented beta convergence in terms of population growth, highlighting some very sparsely populated municipalities that exhibited impressive growth rates all the way through to the mid-twentieth century.

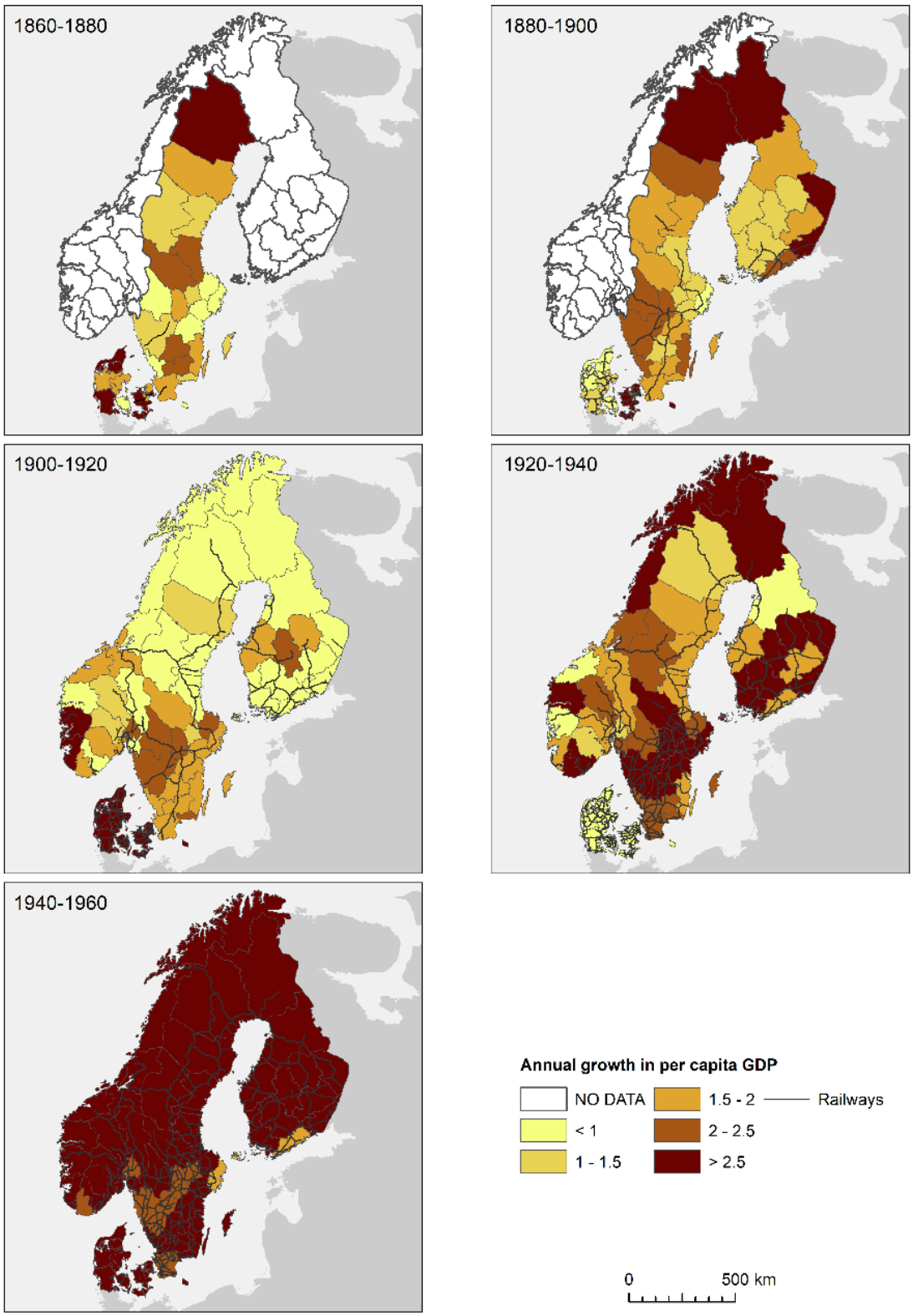
The Nordic countries stand out under international comparison. Their regional inequalities in terms of per capita GDP were relatively large during the early phases of industrialisation, but unlike in other European states, these inequalities did not subsequently grow. Instead, industrialisation had a balancing effect throughout the twentieth century and in 1980 the Nordic economies exhibited extraordinarily small regional inequalities. By reducing regional inequality and sparking catching-up processes in previously backward areas, we would argue that transportation played an important role in the inception of a Nordic model that engendered economic growth.

[51] Heckscher, E. 1954. An Economic History of Sweden. Harvard University Press, Cambridge (1954)

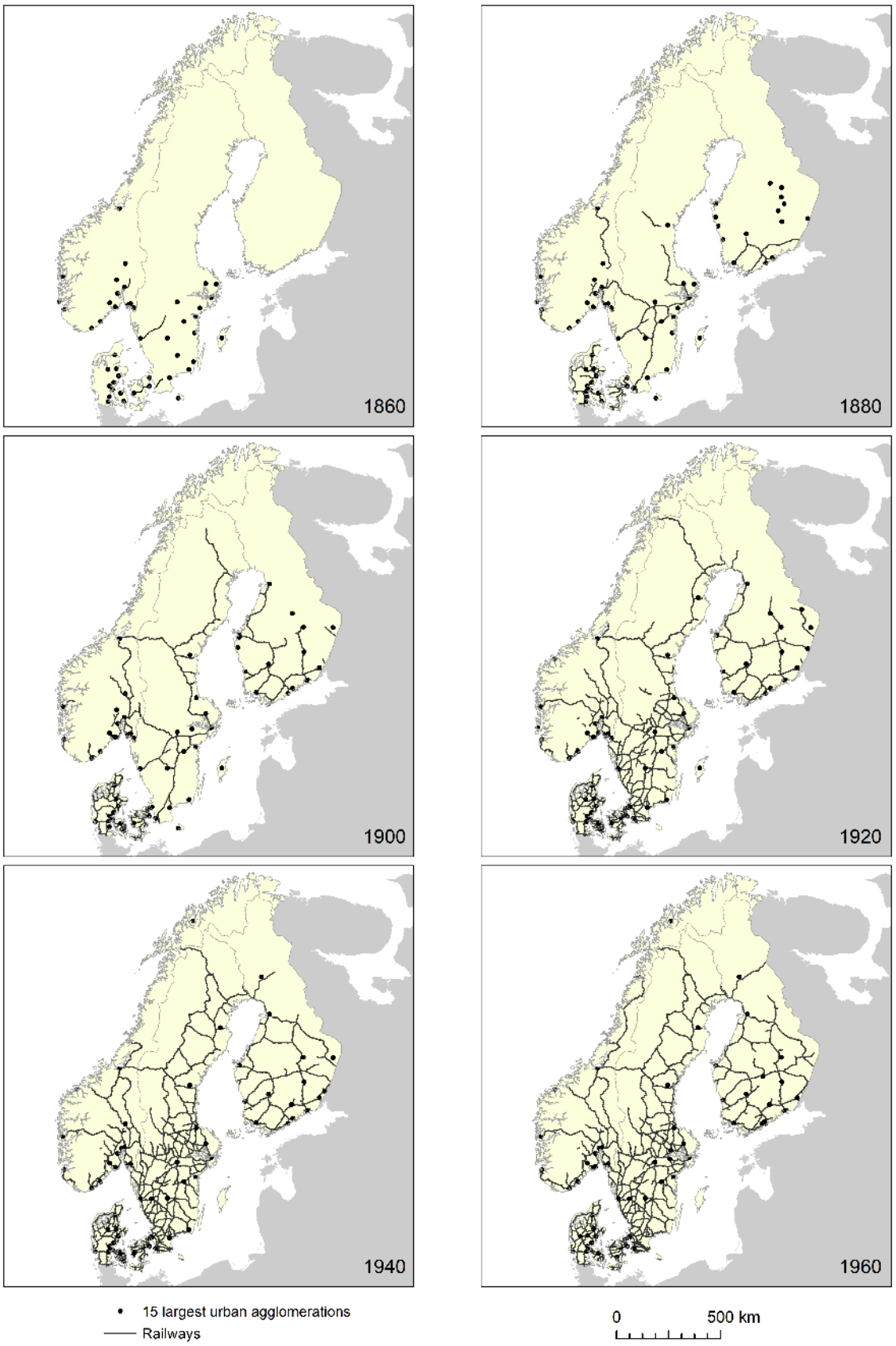
APPENDIX



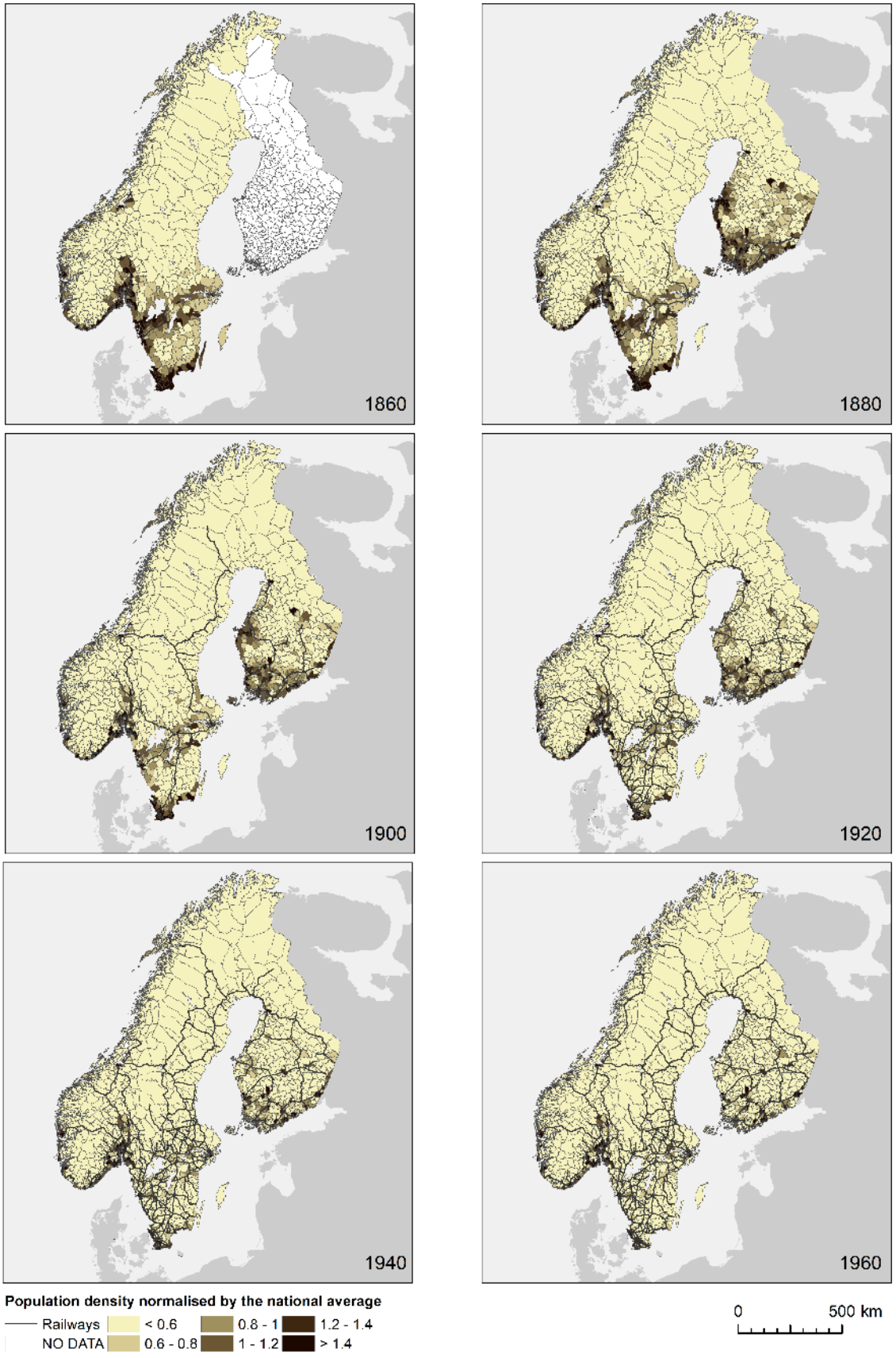
Poster 1. Regional per capita GDP. Sources: Sweden: Enflo et al. (2014); Finland: Enflo (2014); Norway: Modalsli (forthcoming); Denmark: Janisse, Sandholt and Sharp (forthcoming).



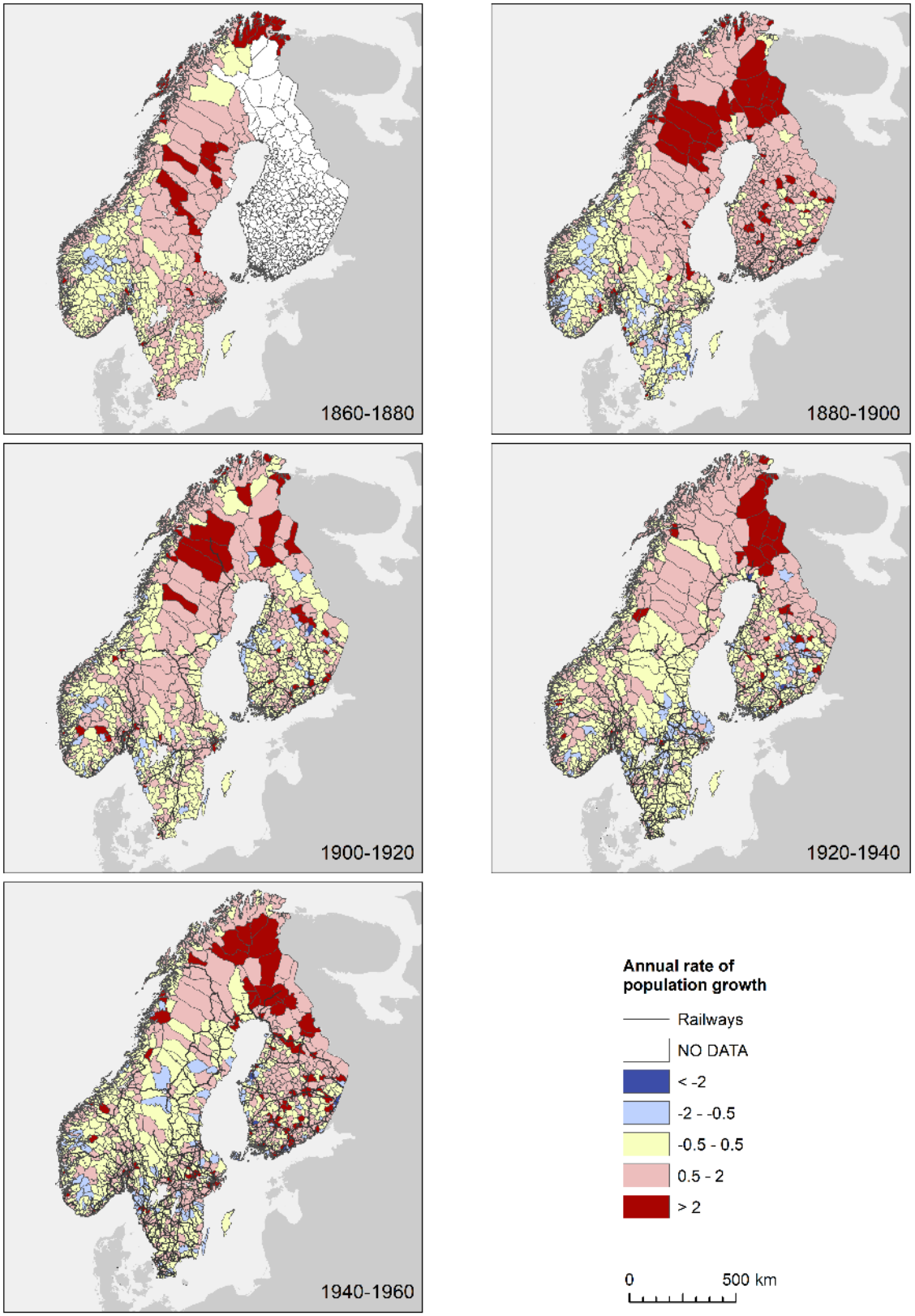
Poster 2: Growth in regional per capita GDP. Sources: Sweden: Enflo et al. (2014); Finland: Enflo (2014); Norway: Modalsli (forthcoming); Denmark: Janisse, Sandholt and Sharp (forthcoming).



Poster 3: Railways and the fifteen largest urban agglomerations in each country. Sources: Railways from HGISe project, Urban Agglomerations from eGeopolis project.



Poster 4: Population density normalised by national average. Sources: Norway: Statistikkbanken; Sweden: Umeå Demographic Data Base FOLKNET, Finland: National Institute of Statistics. Railways from HGISe project.



Poster 5: Population growth rates by municipalities. Sources: Norway: Statistikkbanken; Sweden: Umeå Demographic Data Base FOLKNET, Finland: National Institute of Statistics. Railways from HGISe project.